United States Patent [19]

Kahan et al.

[11] **3,983,718**

[45] **Oct. 5, 1976**

[54] **KNITTING MACHINE FOR PRODUCING PROGRAMMED DESIGNS**

[75] Inventors: **William Kahan,** New York, N.Y.; **Howard D. Rogers,** Fanwood; **Frederick A. Rupinski,** Lyndhurst, both of N.J.

[73] Assignee: **The Singer Company,** Elizabeth, N.J.

[22] Filed: **Sept. 12, 1975**

[21] Appl. No.: **612,815**

[52] **U.S. Cl.** ..... **66/75 A**

[51] **Int. Cl.²** **D04B 7/24**

[58] **Field of Search** ..... 66/75 A, 60, 64, 154 A

[56] **References Cited**

UNITED STATES PATENTS

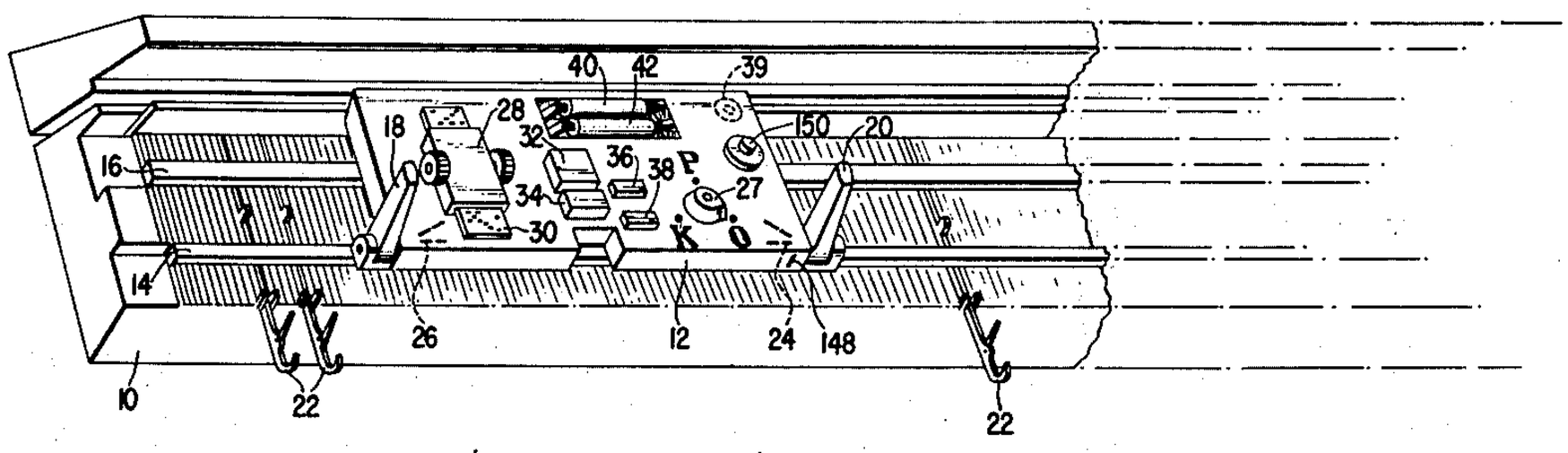
2,157,989	5/1939	Lawson	66/75
3,518,845	7/1970	Decerjat	66/75 A X
3,783,642	1/1974	Hadam	66/75 A
3,818,728	6/1974	Erb	66/75 AA
3,885,405	5/1975	Manfred	66/154 A
3,913,353	10/1975	Spencer	66/75 A

Primary Examiner—Ronald Feldbaum
Attorney, Agent, or Firm—Edward L. Bell; Robert E. Smith; William V. Ebs

[57] **ABSTRACT**

The carriage of a home knitting machine is provided with a reader operable independently of any movement of the carriage of the machine for reading out patterning instructions on a programmed card prior to knitting, an electronic memory for storing the signals read from the card, and means for recalling the stored signals from the memory in synchronization with movement of the carriage during knitting and for causing the operation of needle selectors on the carriage in accordance with the recalled signals to provide for the formation in a fabric of a pattern defined on the card.

10 Claims, 8 Drawing Figures



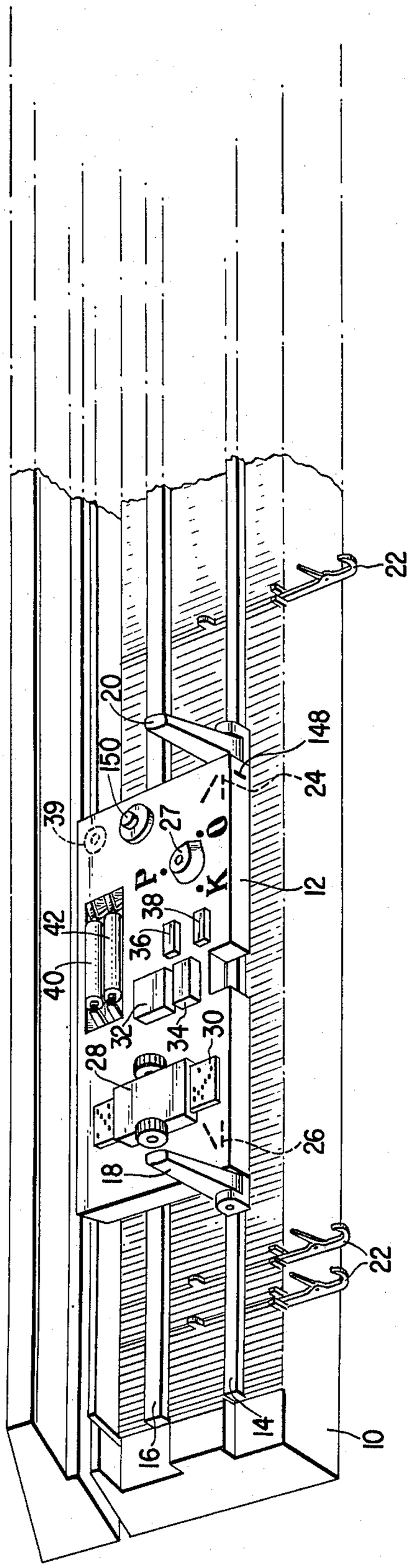

22
20
150
148
24
39
27
12
42
38
36
40
32
34
30
28
26
18
22
16
14
10

Fig. 1

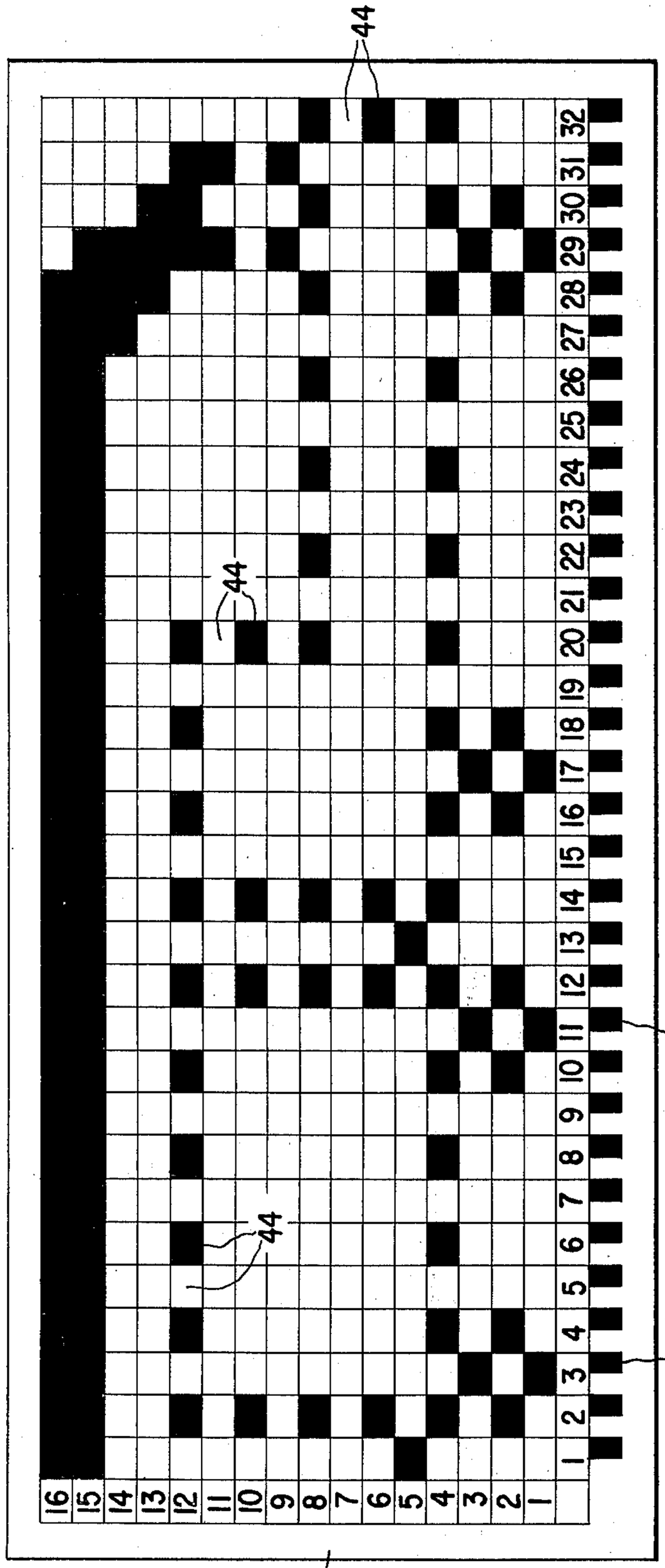

44
44
44
46
46
30
32 31 30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32

Fig. 2

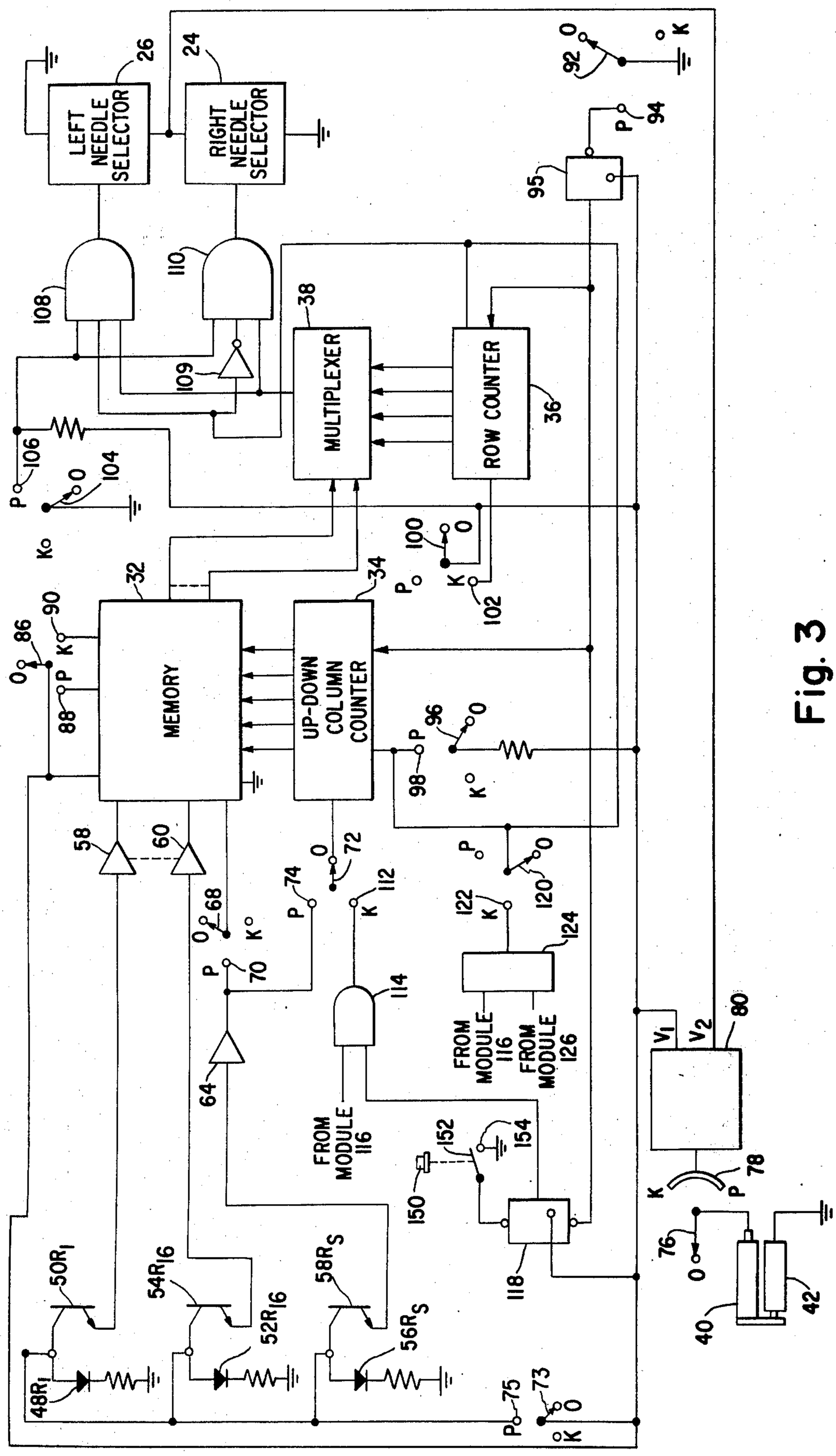

LEFT NEEDLE SELECTOR
26
RIGHT NEEDLE SELECTOR
24
92
O
K
94
P
95
108
110
109
38
MULTIPLEXER
ROW COUNTER
36
106
104
100
102
32
34
90
86
88
MEMORY
UP-DOWN COLUMN COUNTER
96
98
58
60
72
74
68
70
64
112
114
120
122
124
FROM MODULE 116
FROM MODULE 126
80
V_1
V_2
78
76
40
42
150
152
154
118
$50R_1$
$48R_1$
$54R_{16}$
$52R_{16}$
$58R_S$
$56R_S$
75
73

Fig. 3

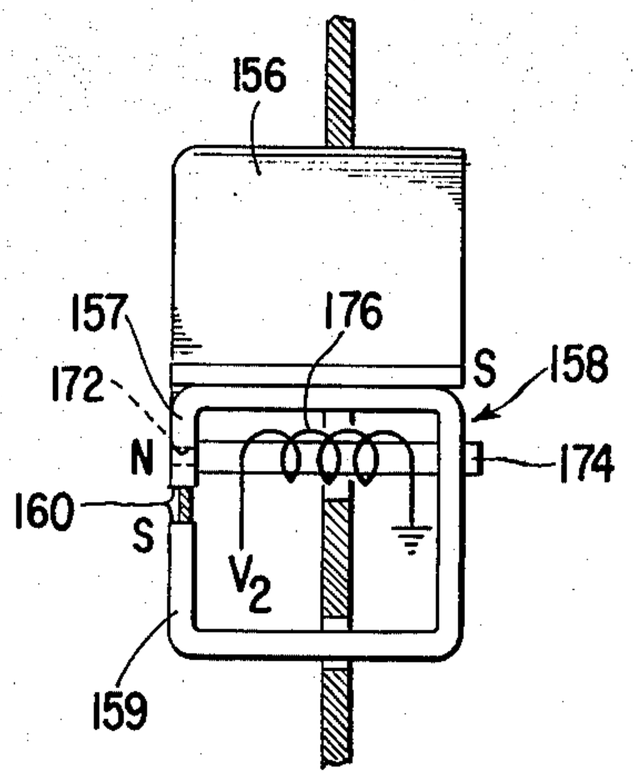


Fig. 7

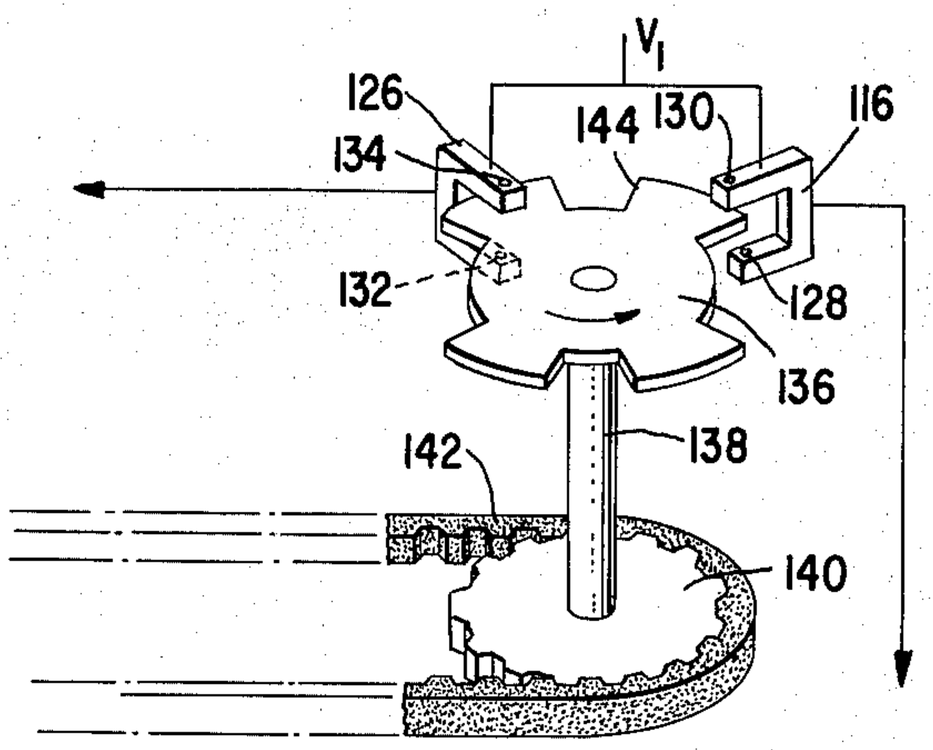


Fig. 4

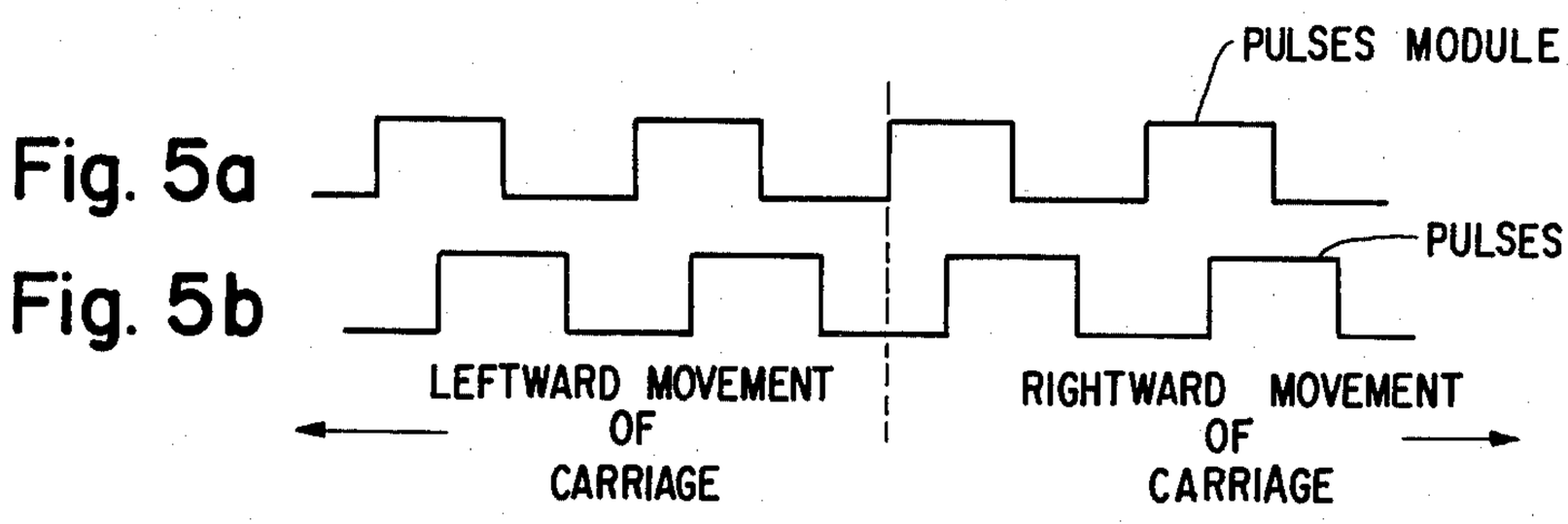


Fig. 5a

Fig. 5b

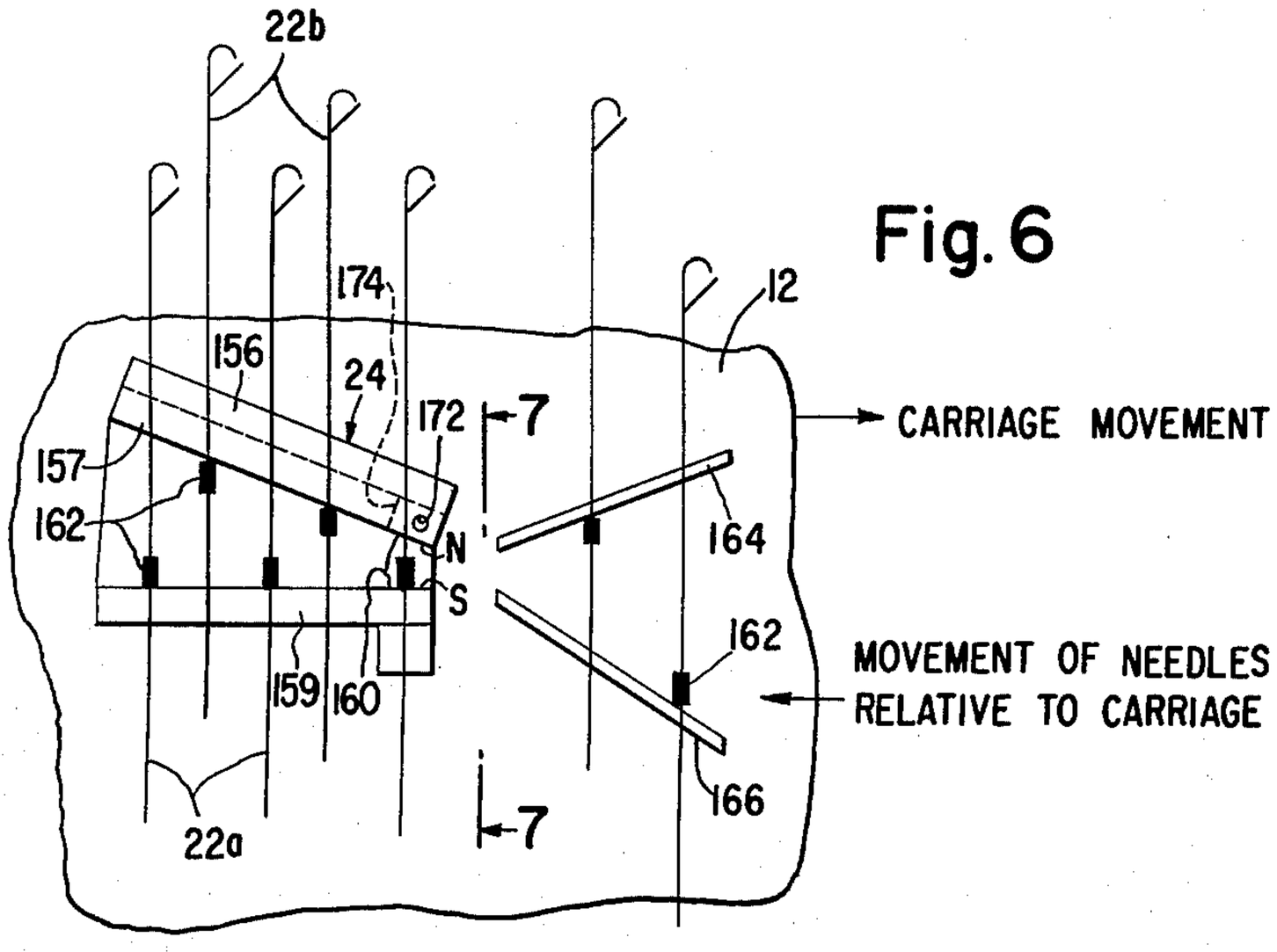


Fig. 6

KNITTING MACHINE FOR PRODUCING PROGRAMMED DESIGNS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to flat bed knitting machines which can be programmed to produce prescribed designs in a fabric and has particular application to home knitting machines.

2. Description of the Prior Art

Programmable home knitting machines which pick up patterning instructions photoelectrically one row at a time from a program card on each knitting stroke of a carriage and utilize such instructions during the following knitting stroke are known and are exemplified by the machines of U.S. Pat. No. 3,885,405 and Japanese laid-open Pat. 85853/73. It is a disadvantage of such machines that they must pick up patterning instructions while the carriage moves at knitting speed, since this complicates the design problem and increases cost. In such machines a movable photoelectric reading head scans data on a program card which is stationary on the bed, and because of the speed at which the carriage may be moved high quality and therefore costly light emitting diodes (LED's) and phototransistors must be used in the reading head if the card is to be read accurately. It is also difficult to obtain accurate readings in such machines because there is no convenient way of shielding the programmed card from ambient light. Accuracy in the reading of a card on the bed by a reading head on the carriage is also difficult to obtain because of the liberal tolerances which must be provided between the carriage and the bed, the liberal tolerances being required to assure that any carriage or bed of any machine can be substituted for any other in the production line such that they may be produced at a reasonable cost.

SUMMARY OF THE INVENTION

In the home knitting machine for the invention, an enclosed card reader is provided on the carriage of the machine. A program card bearing patterning instructions is moved through the reader by an operator and all of the data on the card is read prior to knitting during one pass of the card through the reader. The operation of the reader does not depend upon movement of the carriage and the card may be read as slowly as the operator pleases. A memory capable of storing all of the data read from the card is provided on the carriage and the memory is loaded as the card is read. When the carriage of the machine is operated to knit fabric, signals representing the data stored in the memory are recalled from the memory by sequencing control means including a pulse generator on the carriage which produces control pulses in synchronization with the carriage movement and causes needle selectors also on the carriage to be operated in accordance with the data signals and so provide for the reproduction in a fabric of the design on the card.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a home knitting machine according to the invention;

FIG. **2** is a plan view of a program card for use with the knitting machine;

FIG. **3** is a block diagram showing components of the control system of the knitting machine of the invention and their interrelation;

FIG. **4** is a schematic view in perspective of the pulse generator of said control system;

FIG. **5** (*a* and *b*) are diagrams showing the signal outputs of components of the pulse generator;

FIG. **6** is a somewhat schematic fragmentary botton plan view of the carriage illustrating the operation of one of the needle selectors of the machine of the invention and;

FIG. **7** is a view taken on the plane of the line **7—7** of FIG. **6.**

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. **1** of the drawings, reference characters **10** and **12** designate the bed and carriage respectively of the home knitting machine of the invention. The carriage is slidably mounted on guide rails **14** and **16** affixed to the bed, and includes handles **18** and **20** which an operator may grasp and utilize to move the carriage back and forth on the bed. Knitting needles **22** are supported in side by side relation in the bed **10** and are caused to follow a selected path through conventional camming in the carriage as determined by the operation of electromagnetic needle selectors **24** and **26.** Such needle selectors are operated according to a prescribed design and the needles **22** being thereby caused to move along one path or another through the carriage camming select either a base or a secondary yarn.

The needle selectors **24** and **26** are responsive to the operation of a control system which is wholly carried by the carriage **12** and includes a control switch **27** (OPK switch); a photoelectric reader **28** capable of detecting an entire design indicated on a program card **30** during one pass of the card through it; a silicon memory **32** capable of storing all of the patterning instructions read by the card; and sequencing control means including an up-down column counter **34** which regulates the admission and recall of signals to and from the memory, a row counter **36** and multiplexer **38** which regulate the recall of signals from the memory, and a pulse generator **39.** The memory associated control components **34, 36** and **38** may be on separate silicon chips as shown or incorporated into a single chip with the memory. Batteries **40** and **42** may be utilized as the power supply for the control system and mounted on the carriage as shown to eliminate the necessity of providing power lines between a remote stationary power source and the movable carriage. The OPK switch **27** is a three position switch which an operator may move from a first position O in which the control system is turned off, to a second position P in which the system is conditioned for reading the program card **30** into the memory **32,** from the second to a third position K in which the system is conditioned for knitting a programmed design, and from a third position back to the off position.

The card which may be best seen in FIG. **2** is used to instruct the needle selector control system concerning a design which is to be produced on the knitting machine. As shown the card includes mutually perpendicular lines which define rectangles **44** that extend in numbered columns 1 through 32 and numbered rows 1 through 16. The card also includes a row of strobe markings **46** which are provided for a purpose hereinaf-

ter explained. An operator indicates the design he wishes produced, such as that shown in FIG. **2**, by darkening selected ones of the rectangles **44** on the card with a pencil or other marker (preferably one leaving an erasable mark), and then feeds the card (left end first) through the reader.

The reader includes a paired light emitting diode (LED) and phototransistor for each of the numbered rows on the card and for the row of strobe markings **46.** In FIG. **3** which shown the control system for the needle selectors **24** and **26,** the LED - phototransistor pairs $48R_1 - 50R_1$, $52R_{16} - 54R_{16}$, and $56R_s - 58R_s$ have been illustrated for row **1,** row **16** and the strobe markings respectively, and it is to be understood that like LED — phototransistor pairs are included in the reader for each of rows **2** through **15.** The LED — phototransistor pairs for the rows each connect with the memory **32** through amplifying means, as shown for the LED — phototransistors pairs $48R_1 - 50R_1$ and $52R_{16} - 54R_{16}$ at **58** and **60** respectively. The LED — phototransistor pair $56R_s - 58R_s$ connects through amplifying means **64** with the memory **32** and up-down counter **34** when the OPK switch **27,** which controls the opening and closing of contacts **68** and **70** and of contacts **72** and **74** is in the program position. In any other position of the OPK switch, the LED — phototransistor pair $56R_s - 58R_s$ is disconnected from the memory **32** and from the up-down counter **34.** Contacts **73** and **75** are closed by the OPK switch when the OPK switch is in the program position and contacts **76** and **78,** the opening and closing of which is also controlled by OPK switch **27** are closed when the OPK switch is in either the program or knit position. Each of the LED - phototransistor pairs in the reader is therefore enabled when the OPK switch is in the program position, but not otherwise, by the output voltage V_1 of a voltage converter **80** which has as its potential source, the power supply of the control system, shown as the batteries **40** and **42.** The memory **32** is also enabled by the voltage V_1 whenever contacts **76** and **78** are closed by reason of the OPK switch being in either the program or knit positions, but is not otherwise operable. The voltage converter in addition to providing the voltage V_1 also provides a voltage V_2 at a higher potential for operating the needle selectors **24** and **26.** The OPK switch, when moved from the off to the program position closes contacts **86** and **88** to condition the memory for writing and when moved from the program to knit position closes contacts **86** and **90** to condition the the memory for reading. Contacts **92** and **94** are also closed by the OPK switch when it is moved from the off to program position and as a consequence mono-stable multivibrator **95** (one shot) is caused to produce a voltage pulse which is then applied to up-down counter **34** and row counter **36** presetting them to column address O and row address O respectively. The OPK switch also closes contacts **96** and **98** when it is moved from the off to program position causing a directional signal to be applied to the counter, the signal being such as to cause the counter to count up.

With the OPK switch in the program position, the machine may be programmed to knit the particular design on the program card by feeding the card through the reader. The LED-phototransistor pairs in the reader are all arranged in a line and as a card moves through the reader the columns in the design area of the card, and the strobe markings, each of which is in alignment with the trailing half of a column, appear

successively under the LED-phototransistor pairs. Phototransistor $58R_2$ detects the strobe marks and the other phototransistors detect the presence or absence of markings within the design area of the card. As previously noted the up-down counter **34** was set to address O when the OPK switch was moved from the off to the program position and readings from the first numbered column on the card are therefore recorded in the memory at this address when phototransistor $58R_s$ detects the first strobe mark, a write pulse being then applied to the memory over contacts **68** and **70.** As the card moves through the reader, the counter is incremented by one each time the phototransistor moves beyond the trailing edge of a dark strobe mark to a light area and signals from the various columns are successively recorded as the dark strobe markings are detected causing a write pulse to be applied to the memory. The memory **32** is in the form of a semiconductor chip and is of a well known type of which Intel's P/N 2101, Signetics 2606 and the industry wide P/N 1103 are examples. The up-down counter **34** is also a semiconductor chip of a known type of which Texas Instruments Counter P/N 74191 is an example.

After the program card has been read, the OPK switch may be moved from the program to knit position to ready the machine for knitting. When the OPK switch is so moved it opens contacts **68** and **70** to disconnect the phototransistor $58R_s$ from the memory and opens contacts **72** and **74** disconnecting phototransistor $58R_s$ from the column counter **34.** Contacts **100** and **102** which are open in the off and program positions of the OPK switch are closed thereby causing voltage V_1 to be applied as an enabling voltage to the row counter **36.** Contacts **104** and **106** which are closed in the program position of the OPK switch and then cause a disabling voltage signal (ground potential) to be applied to AND gates **108** and **110** are opened when the OPK switch is moved to the knit position whereupon the disabling voltage signal is removed from the gates rendering the needle selectors operable. Contacts **72** and **112** are closed to connect the up-down counter to AND gate **114** which responds to signals from a photo-interrupter module **116** of the pulse generator **39** and a flip-flop **118,** and contacts **120** and **122** are closed to connect the up-down counter and row counter to a flip-flop **124** which responds to signals from the aforesaid photo-interrupter module **116** and to a second photo-interrupter module **126** of the pulse generator.

The photo-interrupter modules of the pulse generator (See FIG. **4**) each include a light emitting diode (LED) and phototransistor as shown for module **116** at **128** and **130** respectively and for module **126** at **132** and **134** respectively, such LED's and phototransistors as shown being located on opposite sides of a toothed wheel **136** in the pulse generator. The toothed wheel **136** is affixed to a shaft **138** which is mechanically linked through a toothed pulley **140,** also affixed to the shaft, and a timing belt **142** to gearing (not shown) as, for example, a pinion on the carriage and rack on the bed of the machine for driving the wheel as the carriage is moved across the bed. The wheel **136** moves in synchronism with the carriage and equally spaced teeth **144** on the wheel intermittently interrupt light between the LED and phototransistor in each of the photo-interrupter modules causing the modules to produce output pulses. Modules **116** and **126** are so located and the number of teeth **144** on wheel **136** is such as to cause

module **116** to produce a counting pulse (FIG. 5*a*) each time the carriage passes from one needle area of the bed to the next, and module **126** to produce pulses (FIG. 5*b*) which lead the pulses from module **116** by 90° when the carriage is moved in one direction (to the right) and which lag the pulses from module **126** by 90° when the carriage is moved in the other direction (to the left). The output signal from module **116** controls the up-down counter **34** of FIG. **3**, and the output signals from module **116** and **126** jointly control the operation of flip-flop **124** and so cause the flip-flop to provide an output signal indicative of the direction of movement of the carriage.

With the machine readied for knitting an operator choses one of the needles in the bed to knit the design fragment indicated by the presence or absence of a mark in column one, row one, on the program card. This is accomplished by the operator positioning the carriage so that the right needle selector may act first upon the chosen needle during knitting (the appropriate position being defined by the alignment of a mark **148** on the carriage with the said needle), and by the operator then depressing button **150** on the carriage to momentarily close contacts **152** and **154** (See FIGS. **1** and **3**). The closing of contacts **152** and **154** sets flip-flop **118** which then provides an input to gate **114** permitting the up-down counter to be incremented or decremented in response to the operation of a photo-interpreter module **116.**

The machine is threaded with a secondary yarn as required for knitting the design pattern in a base yarn previously cast on the machine and the carriage is moved first to the right and then back and forth across the bed to knit the design on the card. Initially column **1** information is read out of the memory since the up-down counter is at address O when button **150** is depressed (the counter having been so set when the OPK switch was moved from the off to program position closing contacts **92** and **94**), and row **1** is selected by the row counter **36** and multiplexer **38** since the row counter is then also at **0.** As the carriage is moved to the right on the bed beyond the chosen needle, up-down counter **34** responding to the operation of module **116** is incremented once each time the carriage moves over a new needle location. The counter is thereby caused to sequentially address the **32** columns of information in the memory and after each **32** counts repeat the process. Such column information is read into the multiplexer and the multiplexer which is at address O selects from each column the information in row one. During the said first knitting stroke of the carriage to the right a directional signal from flip-flop **124** directly transmitted to the gate **108** and through an inverter **109** to gate **110** causes the right needle selector **24** to be operated in response to signals from the multiplexer to the gates but prevents the operation of the left needle selector.

After the carriage has been moved beyond the fabric being knitted the operator reverses its direction causing it to be moved to the left whereupon the row counter is incremented by one and the up-down counter is caused to count down rather than up, both changes being effected in response to a changed directional signal from flip-flop **124.** The up-down counter is decremented by one count as each needle location is traversed by the carriage, the column information is extracted from the memory in reverse order sequentially and repetitively, and the multiplexer because of the changed row selects the information in row **2** of each of the columns. By reason of the changed directional signal at flip-flop **124** which is reflected at gates **108** and **110,** the left needle selector is caused to operate in response to output signals of the multiplexer transmitted to the gates and the right needle selector is prevented from operating. As the carriage moves to the left such left needle selector is operated to cause that portion of the design appearing in the second row on the program card to be knitted repetitively across the fabric. Successive rows of the design are formed in successive courses of the fabric knitted on the machine as the carriage is moved back and forth across the machine bed. Sixteen rows of design are produced in as many courses of fabric and the entire design is reknitted each time sixteen courses have been completed, such repetition being controlled by the row counter which counts up to **16** and then repeats such counting process. The row counter **36** is a semiconductor chip and is similar to the column counter **34** but lacks the up-down feature. An example of a suitable row counter is Texas Instruments counter P/N 74161.

The needle selectors **24** and **26** are without moving parts and rely solely on magnetic force to influence the positions of needles. Other types of needle selectors having moving parts that actuate needles and so influence their position might be used instead. The needle selectors **24** and **26,** both of which are alike, function during movement to the right and left, respectively, of the carriage in a manner made apparent in FIGS. **6** and **7.** The selector **24** includes a permanent magnet **156** fastened against the upper limb **157** of a C-shaped channel **158** of magnetic material having a lower limb **159.** The upper and lower limb **157** and **159** of the channel **158** define a gap **160** which diverges toward the left as shown in FIG. **7** and presents opposing north and south magnetic poles as indicated. Needle butts **162** move through the selector as the carriage is moved on the bed of the machine and are caused by guides **164** and **166** to pass into the narrowest portions of the gap **160.** A hole **172** is formed in the limb **157** adjacent to the narrowest portion of the gap **160** which so reduces the strength of the upper or north pole of the opposed magnetic poles developed solely by the permanent magnet **156** that needle butts guided into the gap **160** will be attracted to the lower or South pole against limb **159** and thereafter continue along limb **159** (needles **22***a*) because of the separation caused by the divergence of the pole faces.

A magnetizable core **174** is attached to the upper limb **157** of the channel **158** adjacent to the hole **172** and a coil **176** is so arranged on the core **174** so that when the coil is energized a strong electro-magnetic pole is produced on the core **174** of the same polarity as that produced by the permanent magnet **156** in the gap **160.** When a needle butt is in the gap while the coil **176** is energized, the upper or North magnetic pole of the opposed magnetic poles in the gap will be the strongest pole and will attract that needle butt against the upper limb **157** and it will continue along the upper limb (needles **22***b*) because of the separation caused by the divergence of the pole faces.

Numerous alterations of the structure herein disclosed will suggest themselves to those skilled in the art and it is to be understood that the present disclosure relates to an embodiment of the invention which is for purposes of illustration only. It is not to be construed as a limitation of the invention. All modifications which

do not depart from the spirit of the invention are intended to be included within the scope of the appended claims.

Having thus set forth the nature of the invention, what is claimed herein is:

1. In a knitting machine, the combination comprising a needle bed supporting a plurality of needles in side by side relation, a carriage mounted on the bed for movement traversing such needles, a program card bearing patterning instructions, means on the carriage operable independently of movement of the carriage for reading out the patterning instructions on the card, a memory on the carriage connected with the reading means for storing signals representing said patterning instructions, needle selecting means on the carriage operably connected with the memory, and sequencing control means operably connected with the memory for causing said signals representing the patterning instructions to be recalled from the memory whereby they may be utilized to control the operation of the needle selecting means when the carriage is moved on the bed of the machine for the purpose of knitting fabric, the sequencing control means including a pulse generator on the carriage operable in timed relation to movement of the carriage.

2. The combination of claim **1** includng a power source on the carriage for the reading means, memory, needle selecting means, and sequencing control means.

3. The combination of claim **1** including switch means operatively connected with the reading means, memory and needle selecting means, the switch means having one position wherein operation of the reading means and memory is enabled but operation of the needle selecting means is prevented, and having another position wherein operation of the memory and needle selecting means is enabled but operation of the reading means is prevented.

4. The combination of claim **1** wherein erasable marks on the card in conjunction with unmarked portions of the card define a pattern to be knit.

5. The combination of claim **1** wherein the reading means is stationary on the carriage and the card is moved relative to the reading means to permit patterning instructions on the card to be detected by the reading means.

6. The combination of claim **1** wherein the sequencing control means includes means for repetitively counting out a series of signals from the memory corresponding to patterning instructions in a row on the card as the carriage traverses the bed of the machine, control means responsive to a change in direction of the motion of the carriage, and other counting means responsive to the directionally responsive control means for rendering the first mentioned counting means effective successively on the series of stored signals corresponding to the rows of instructions on the card, the operation of the last mentioned counting means being repeated after completion of a number of traverses of the carriage corresponding to the number of rows of patterning instructions on the program card.

7. The combination of claim **1** wherein rows and columns of patterning instructions on the card denote a design to be produced in courses and wales of a fabric, said combination including switch means operable to chose a particular needle defined by a selected position of the carriage on the bed for a particular fragment of the fabric, the switch means when operated being effective to cause the sequencing means to select from the memory a signal corresponding to the patterning instruction for said fragment and said sequencing means being operable in response to movement of the carriage from the needle defining position such that when knitting, the design may be produced repetitively across the fabric in positions consistent with said fragment being formed on the chosen needle.

8. The combination of clam **7** wherein said switch means is on the carriage.

9. In a knitting machine, the combination comprising a needle bed supporting a plurality of needles in side by side relation, a carriage mounted on the bed for movement traversing such needles, a program card bearing patterning instructions, means operable independently of movement of the carriage for reading out the patterning instructions on the card, a memory connected with the reading means for storing signals representing said patterning instructions, needle selecting means on the carriage operably connected with the memory, and sequencing control means operably connected with the memory for causing said signals representing the patterning instructions to be recalled from the memory whereby they may be utilized to control the operation of the needle selecting means when the carriage is moved on the bed of the machine for the purpose of knitting fabric, the sequencing control means including a pulse generator on the carriage operable in timed relation to movement of the carriage.

10. The combination of claim **9** wherein during one pass of the program card through the reader the reading means detects and the memory records all instructions on the card.

* * * * *